IMPROVING THE BUILT ENVIRONMENT

CARB

Moisture Monitoring in Exterior Walls

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Overview of Presentation

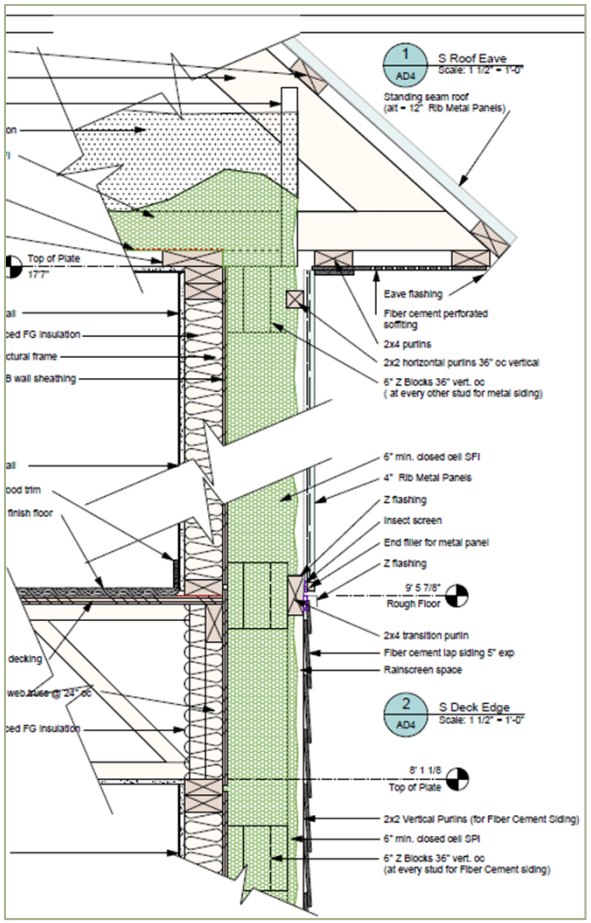
- Project Summary
- Reasons for research
- Questions to be answered
- Modeling
- Field Testing
- Analysis

Project Summary

- Evaluate potential for moisture problems in 3 new wall assemblies
- Modeling – this year
  - WUFI
  - THERM
- Field Monitoring – beginning 2012
  - Brick rehab
  - High-R walls: R-40 & 60
  - Code walls: hybrid insulation w/ spray foam & fiberglass

Reasons for Research

- Changes in construction due to:
  - Drastic increase in retrofit activities
  - Programs like PH & NZEH challenges
  - Increased use of hybrid insulation strategies
  - New insulation products
  - Code changes



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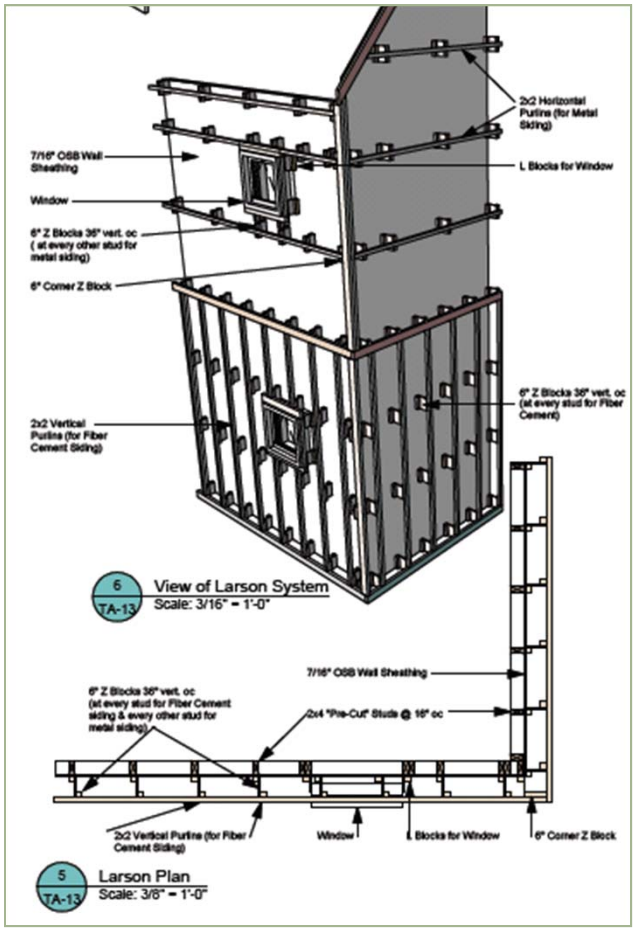
Reasons for Research

- Changes include:
  - Increased use of foam insulation
  - Increasing thickness & R-value of walls
  - Increased use of hybrid insulation strategies
  - Changes in vapor retarder/barrier strategies

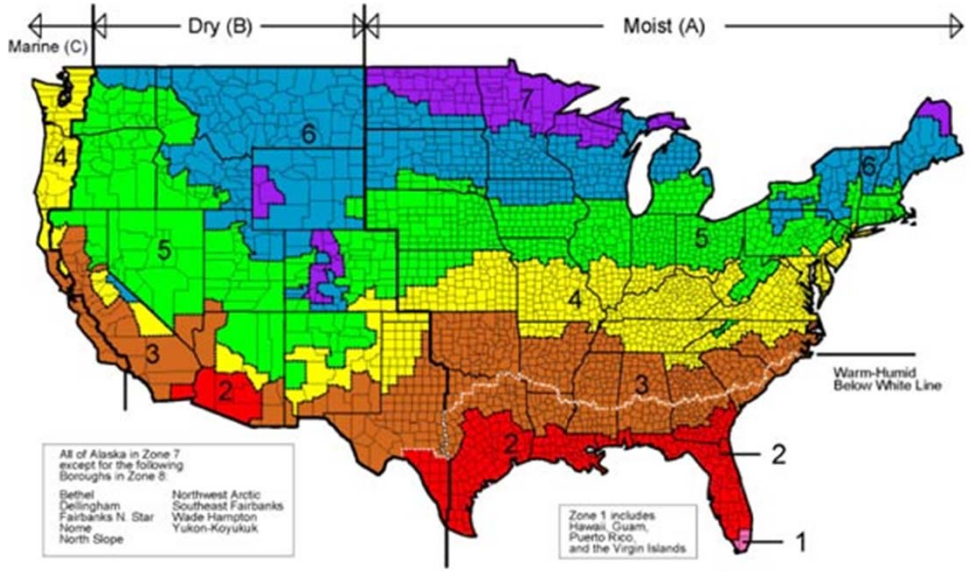


Research Focus

- Assemblies
  - Brick walls with interior insulation;
  - Super insulated walls at least 12” thick: R-40 and R-60;
  - Code built walls using spray foam insulation and fiberglass batts.

Research Focus

- Climate zones 4A, 5A, 6A and 7
  - experience both cooling and heating seasons
  - considerable humidity during the summer



Questions to be Answered

- How does WUFI modeling compare to actual monitored moisture levels?
- What combinations of building and insulation products produce a durable, efficient wall assembly?
- Do any of the monitored wall systems show moisture accumulating? If so, where?

Questions to be Answered

- If high moisture conditions exist, are levels and durations long enough to risk mold and/or decay?
- If high levels of moisture occur, can the cause be determined?
- Can differences in modeling and monitoring be explained?
- Are the R-values specified in Table 601.3.1 of the 2009 IRC sufficient to prevent condensation?

Modeling - WUFI

Table 1. 2009 IRC Code Wall Assemblies to be Evaluated in WUFI

Climate Zone	Medium Density (MD) SPF Insulation (R-value)[1]	Cavity R-value (2009 IRC)[2]
4	2.5 – 7.4	R13
Marine 4[3]	3.75 – 8.6	R20
5	7.5 – 12.4	R20
6	11.25 – 14.5	R20
7	15 – 18.25	R21

[1]Lower R-value in each range is based on the minimum R-value of 2lb foam required by the 2009 IRC, Table R601.3.1 Class III Vapor Retarders.
[2]Climate Zone 4 (A & B) assume 2x4 wall cavity, all others are 2x6.
[3]Marine 4 is moisture regime C.

Modeling - WUFI

Table 1. Brick Wall and High-R Walls to be Evaluated in WUFI

Wall Type	Vapor Retarder	Cavity Insulation	Cavity Insulation Thickness (inches)	Spray Foam Thickness[3] (inches)	Sheathing Type	Sheathing Thickness[4] (inches)
Brick Wall	None, 0.1, 1.0	Fiberglass	2-5	0.5 - 2	n/a	n/a
		Cellulose	2-5	0.5 - 2	n/a	n/a
R-40+[1]	None, 0.1, 1.0	Fiberglass	5-8	2-4	OSB	0.5
				--		2-4
		Cellulose	5-8	2-4	OSB	0.5
				--		2-4
R-60+[2]	None, 0.1, 1.0	Fiberglass	8-12	4-6	OSB	0.5
				-- XPS	XPS	4-6
		Cellulose	8-12	4-6	OSB	0.5
				-- XPS	XPS	4-6

[1]Evaluated in Climate Zones 4 & 5
[2]Evaluated in Climate Zones 6-8
[3]Spray foam will be evaluated in 1" increments
[4] XPS will be evaluated in 1" increments

Modeling - THERM

- WUFI can only analyze continuous components
- Want to analyze condensation potential due to thermal bridging at framing members - THERM

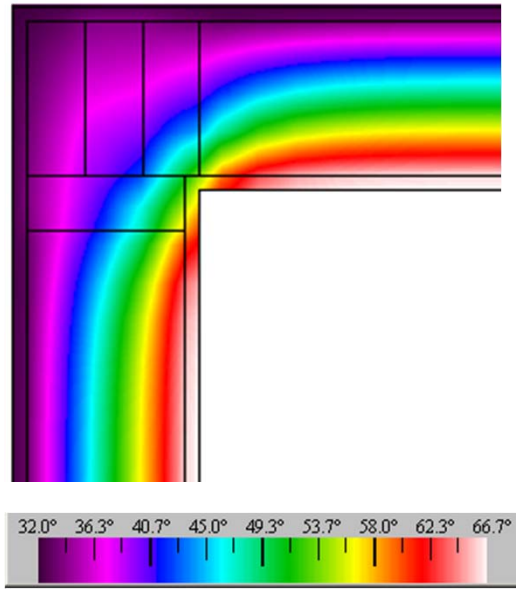


Image from THERM

Field Testing

- Short Term
  - moisture content of components using a hand held moisture meter
  - Adjust values in WUFI if necessary
- Long Term
  - RH & Temp at critical interfaces
  - Moisture content – OSB, brick, studs
  - Climatic conditions

Failure Criteria

- Moisture Content (MC)
- Condensation
- Mold growth
- Critical water content
- Rot/decay
- Freeze-thaw cycles

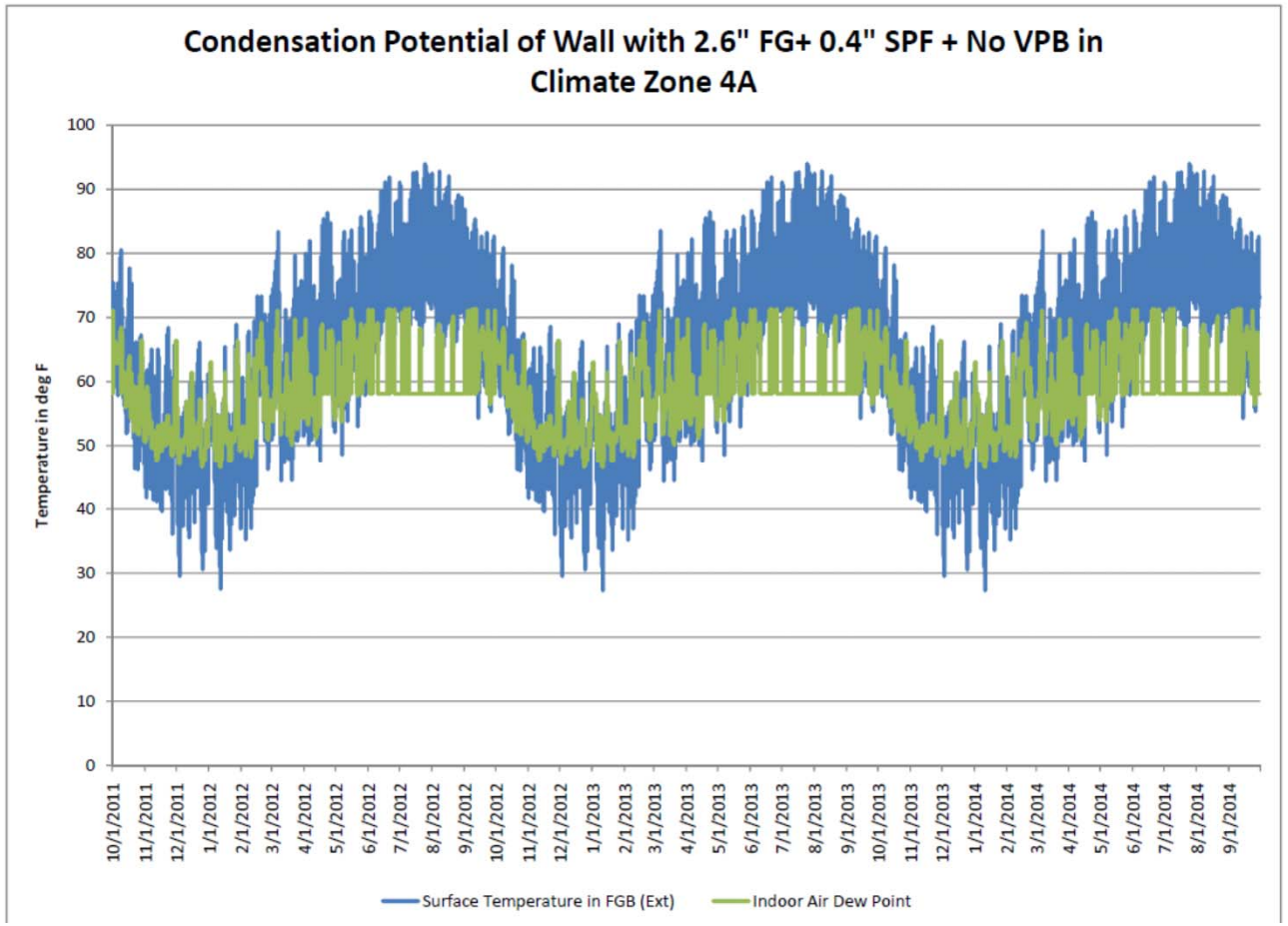
MC & Condensation Potential

- Moisture Content (MC) of OSB < 20%
- Condensation Potential – graph interior air dew point temp vs. surface temp
  - Several interfaces will be analyzed – OSB/foam, foam/cavity insulation, interior surface of brick
  - THERM – framing/OSB, framing/insulation

Moisture Content

Representative City	Wall ID	Climate Zone	FG insulation thickness (in)	MD SPF Ins. Thick (In)	Vapor Barrier Perm rating	Avg. MC in OSB %
Nashville, TN	4A-1	4A	2.6	0.4	None	**12.4**
	4A-2	4A	2.2	0.6	None	**12.0**
	4A-3	4A	1.8	0.9	None	**11.6**
	4A-4	4A	1.4	1.1	None	**11.4**
	4A-5	4A	2.6	0.4	1.0	**10.8**
	4A-6	4A	2.2	0.6	1.0	**10.8**
	4A-7	4A	1.8	0.9	1.0	**10.7**
	4A-8	4A	1.4	1.1	1.0	**10.6**

Condensation Potential



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Mold Growth

- Following conditions must be met:
  - Temperature is between 32^{o} and 122^{o}F,
  - Relative humidity is above 70%,
  - Food is present for the mold,
  - There is sufficient time for germination and growth to occur,
  - Other factors such as pH value, salt content of the substrate, light, oxygen content, surface condition and biotic influences must be favorable for growth

Mold Growth

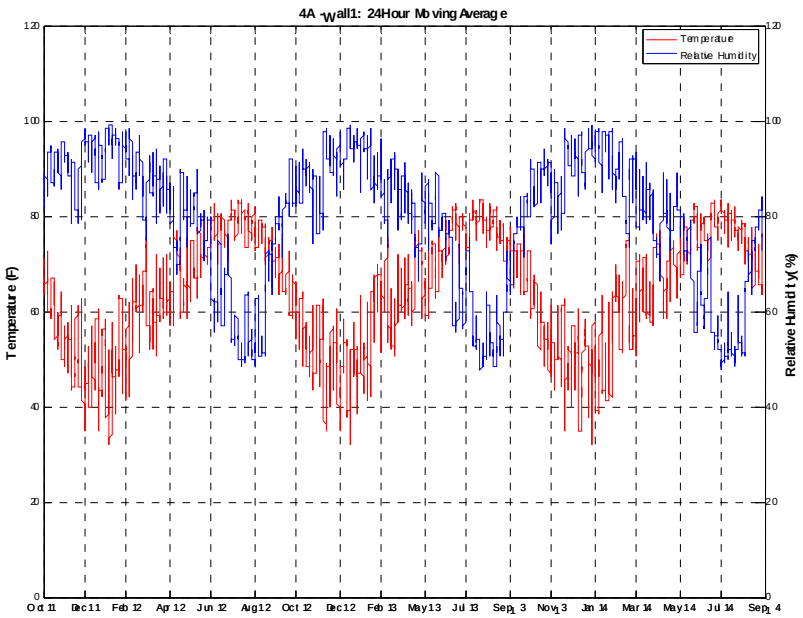
Table 1. Critical Humidity (RH %) Levels for Mold Growth and Decay on Different Materials.

Material	Mold Growth	Decay
Pine sapwood	>80-95	>90
Particle Board	>80-95	>90
Gypsum Board	>80-95	>95
Fiber board	>80-95	>95
Wall papers	>75-95	>90
Different coatings	>75-95	-

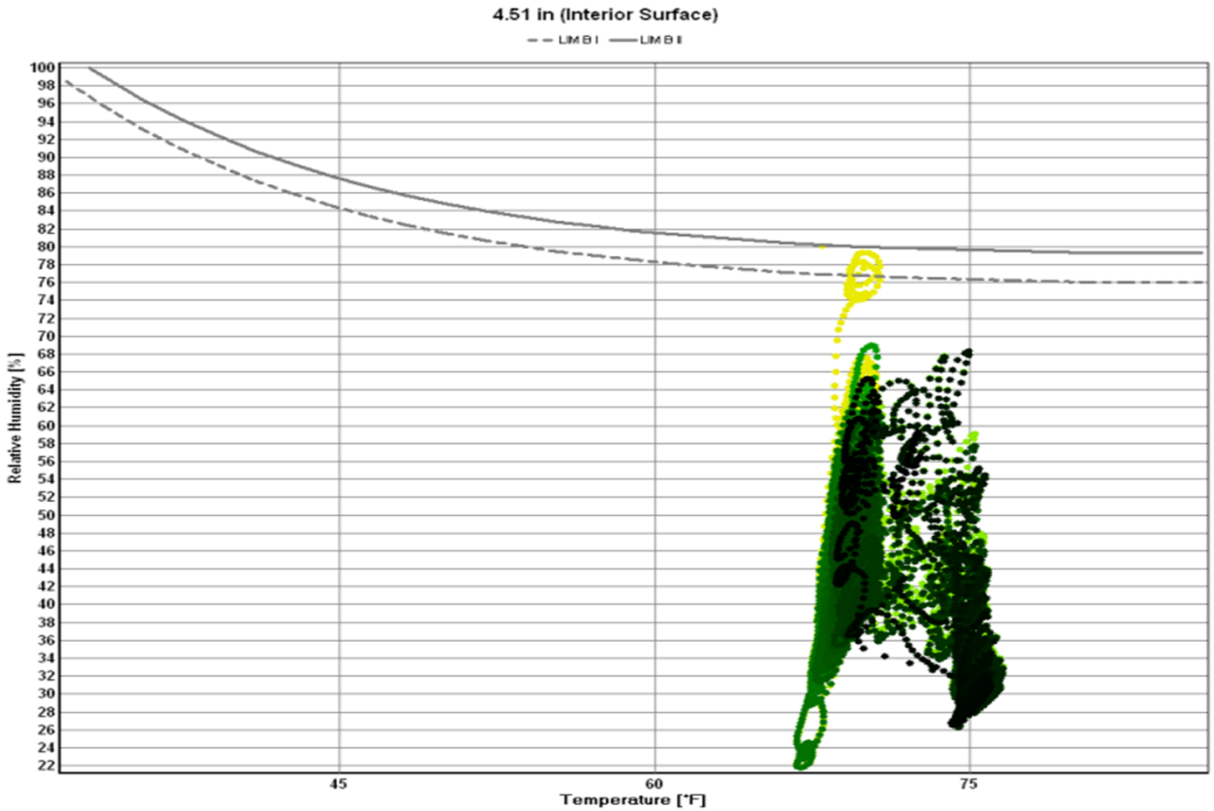
(Table reproduced from ASTM MNL 40)

Mold Growth

- ASHRAE Standard 160 performance criteria:
  - 30–day running average: surface RH<80% & temp 41°F to 104°F
  - 7–day running average: surface RH<98% & temp 41°F to 104°F
  - 24-h running average: surface RH< 100% & temp 41°F to 104°F

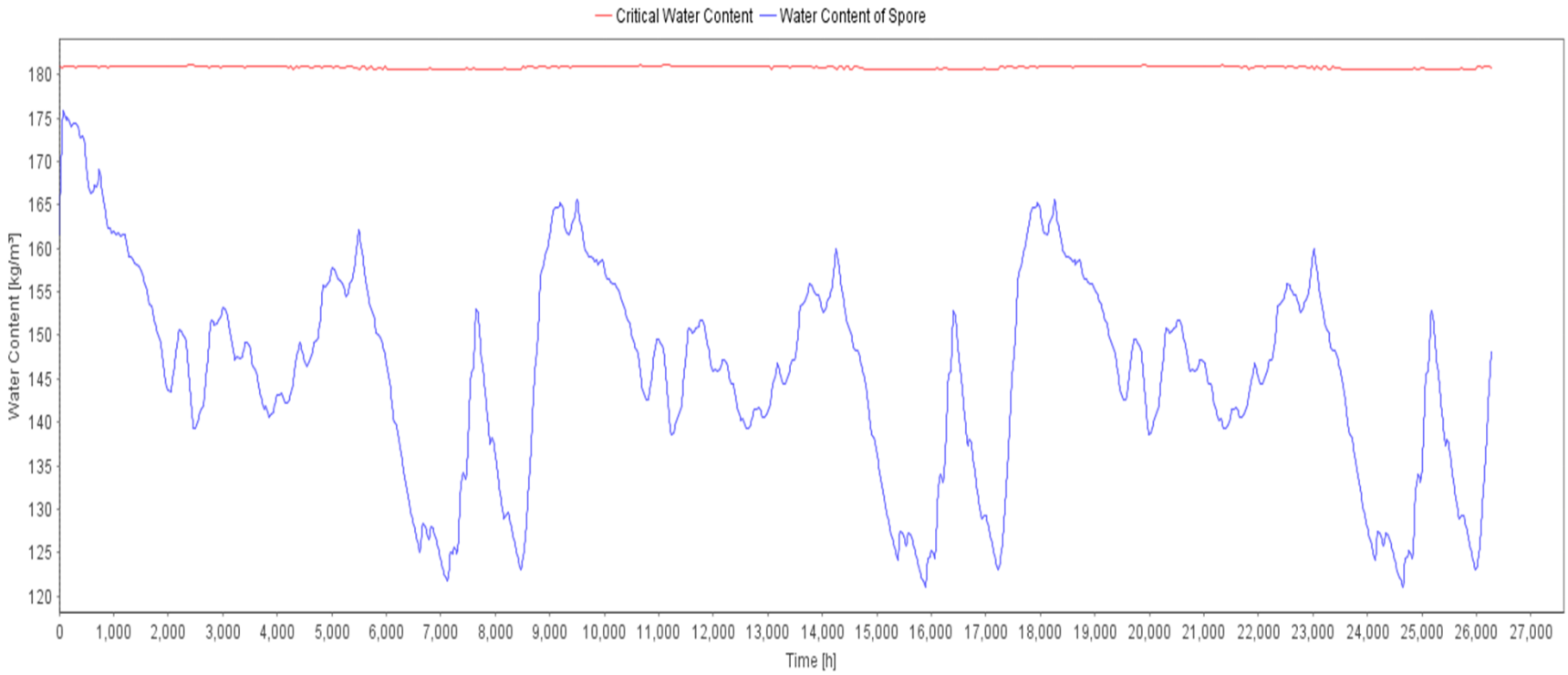


Mold Growth



Isopleth showing mold growth possibility on the interior surface of a wall assembly along with the limiting isopleths

Critical Water Content



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Rot/Decay

- Typical conditions for decay/rot in building materials:
  - RH - 90-95% coincident with
  - Temperature range of 41°F to 104°F.

Freeze-Thaw Damage

- Two factors influence frost damage
  - MC on freezing – critical level for brick 90%
  - Number of freeze thaw cycles – higher number of cycles, more potential for freeze-thaw damage

Questions?

Thank You.